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GB 0916870 A GB 0832685 A EP 0437992 A
EP 0156090 A EP 0105495 A US 5119729 A

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(54) **Shaped charges**

(57) A shaped charge can efficiently transfer energy from an explosive material (12) to create a jet while reducing the effect of shock reverberations on the jet. The shaped charge incorporates a first liner (22) adjacent the explosive material and a second liner (24) having a hollow center. The combination of two liners reduces the effect of shock reverberations on the charge, thereby increasing the jet's cohesiveness and target penetration capability. The first and second liners can be formed as a single liner having at least two liner elements extending outwardly from the liner apex. Multiple liners can be similarly placed adjacent to the other liners in a cascading fashion, or a gap (36) can be incorporated between adjacent liners. A shock absorbing material can be positioned between liners to further attenuate the shock reverberations. Alternatively, such gap can be filled with an explosive material to increase the jet mass. The first liner can be smaller than the second liner to produce a segmented pulse in the jet.

Fig 2.

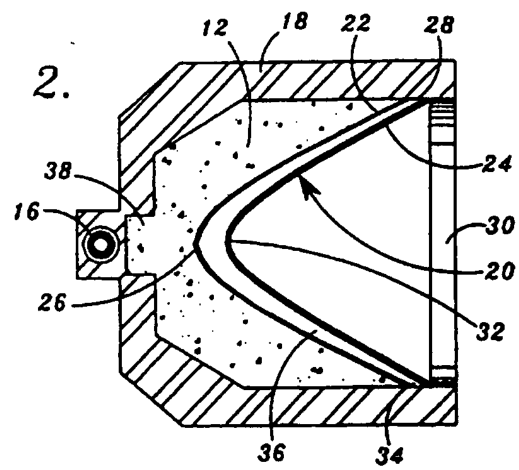

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Fig 1.

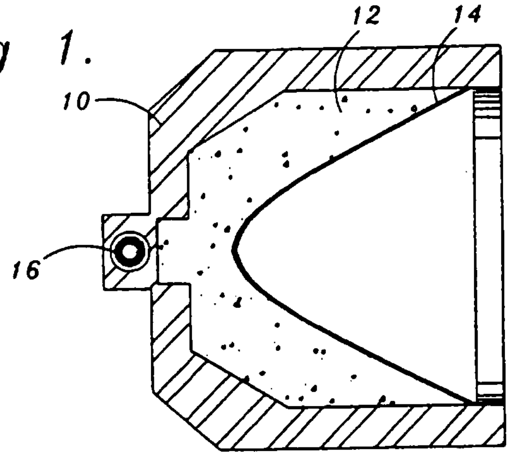


Fig 2.

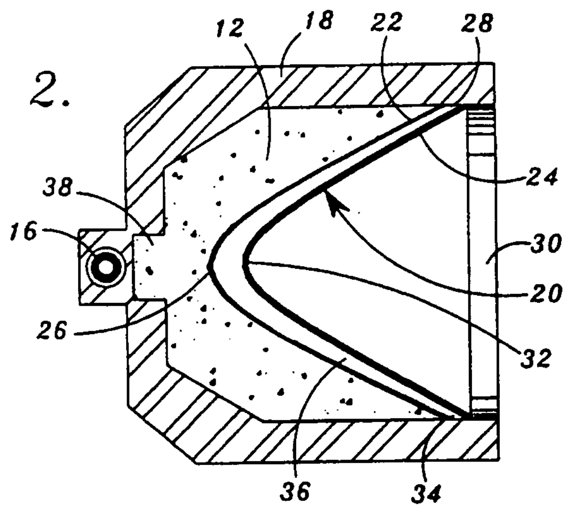


Fig 3.

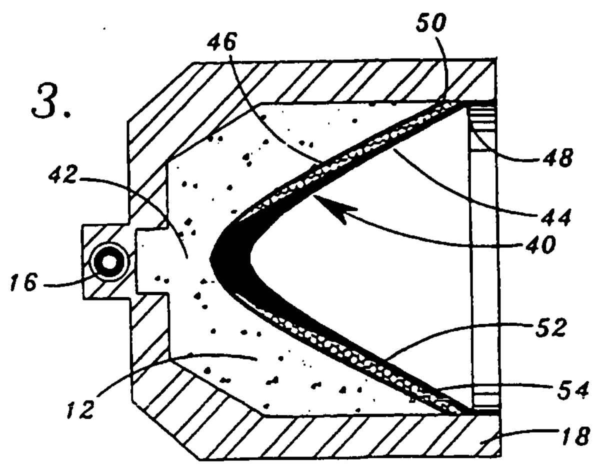


Fig 4.

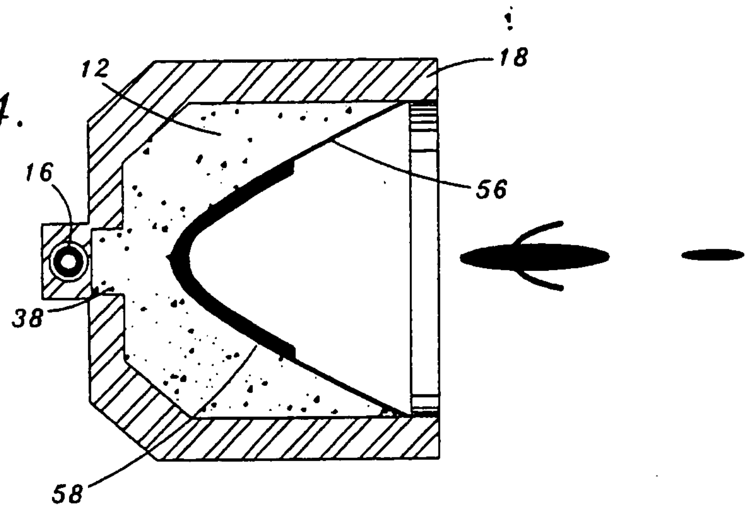


Fig 5.

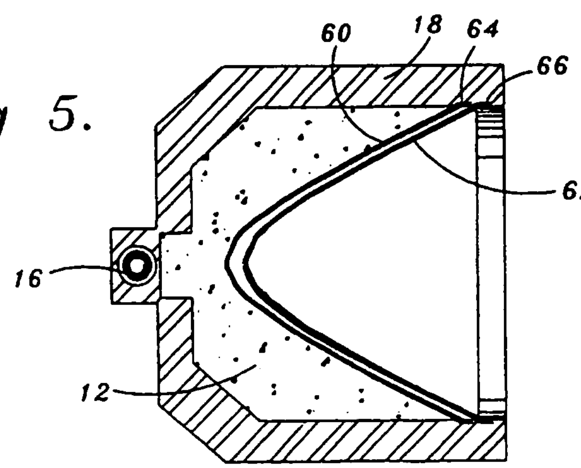


Fig 6.

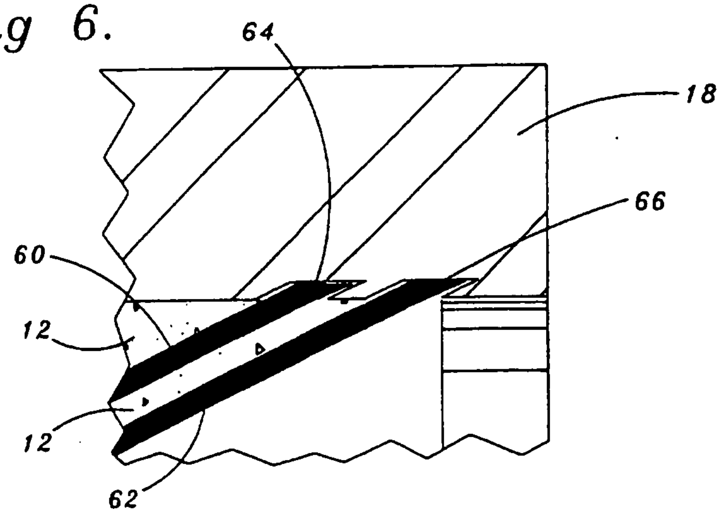
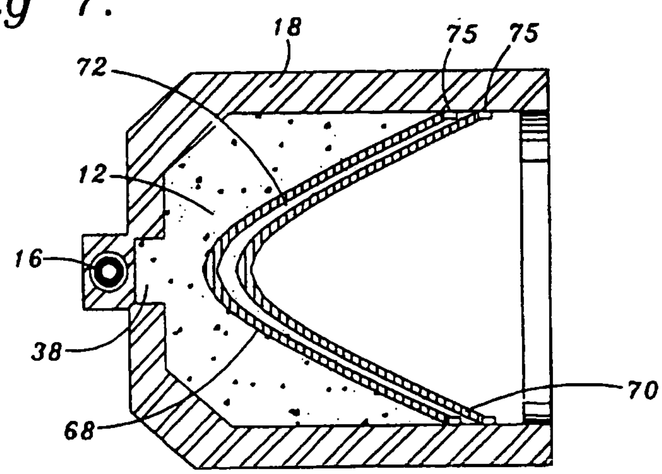


Fig 7.



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SHAPED CHARGES

The present invention relates to shaped charges for generating a metallic jet.

Shaped charges are used in the oil and gas industry and in other fields to pierce metal, concrete, and other solid materials. In an oil or gas well, a metallic casing is cemented to the borehole walls to maintain the borehole integrity. Shaped charges are incorporated in a hollow carrier gun or a strip positioned in the casing. The shaped charges are activated to pierce the well casing and the geologic formation at the hydrocarbon producing zone. The hydrocarbons enter the casing through such perforations and are transmitted to the well surface.

Conventional shaped charges are constructed with a charge case, a hollow conical liner within the case, and a high explosive material positioned between the liner and case. A detonator is activated to initiate the explosive material to generate a detonation wave. This wave collapses the liner and a high velocity metallic jet is formed. The jet pierces the well casing and geologic formation, and a slow moving slug is simultaneously formed. The jet properties depend on the charge shape, released energy, and the liner mass and composition.

The penetrating power of the jet is determined by the jet velocity and other factors. During the collapse of the liner, a significant amount of energy is dissipated due to multiple shock reverberations between the charge case and the liner. These reverberations adversely affect the integrity and efficiency of the jet by interfering with the formation of the jet. This interference weakens the jet and reduces the penetration power of the jet through the well casing and geologic formations.

Accordingly, a need exists for an improved shaped

charge that reduces undesirable interference acting on the jet as it exits the charge case.

Various aspects of the present invention are exemplified by the attached claims.

An embodiment of a further aspect provides an improved shaped charge responsive to a detonator for initiating a material penetrating jet and includes an explosive material formed about an axis which can be initiated by the detonator to create an explosion. A first liner is positioned adjacent to the explosive material, and a collapsable second liner having a hollow center is positioned proximate to the first liner.

In other embodiments of the invention, the first and second liners can be formed as a single liner system having two coaxial liner elements, and the liner ends can be attached to a charge case. A gap can be positioned between the first and second liners, and a shock absorbing material or an explosive can be positioned in such gap. The first liner can be longer than the second liner to create a segmented jet, and multiple liners or liner elements can be similarly positioned within the case to further reduce undesirable shock waves.

For a better understanding of the invention, and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:-

Figure 1 illustrates a conventional shaped charge having a single liner and explosive material within a case;

Figure 2 illustrates an embodiment of the invention having two liner elements within a shaped charge;

Figure 3 illustrates an embodiment of the invention having a single liner system with two liner

elements;

Figure 4 illustrates two liners having different lengths, including a graphic representation showing the resulting segmented jet produced;

Figure 5 illustrates an embodiment in which the distal ends of the liners are attached to a case;

Figure 6 illustrates detail of the attachment between the case and the liner distal ends of the embodiment of Figure 5; and

Figure 7 illustrates another embodiment of the invention showing two liner elements.

An embodiment of the present invention can provide an improved shaped charge that substantially improves the efficiency and penetration of the jet.

Figure 1 illustrates a conventional shaped charge having case 10, high explosive material 12 and conventional liner 14. Detonator 16 initiates a detonation wave in explosive material 12 which travels substantially parallel to the axis of the shaped charge. The detonation wave collapses liner 14, beginning at the apex of liner 14, and creates a metallic jet traveling at high velocities up to 10,000 meters per second and creates a trailing slug traveling at a significantly lower velocity.

As known in the art, the liners for shaped charges can be made with a variety of materials and a variety of geometrical shapes. Liner materials include copper, aluminum, depleted uranium, tungsten, tantalum, and other materials. Representative examples of liner shapes include hemispheres, paraboloids, ellipsoids, pear shapes, and trumpets. A case is not essential to the performance of shaped charges, as a shaped charge can be constructed from the simple combination of a hollowed high explosive and a liner for lining the explosive cavity.

Figure 2 illustrates one embodiment of the present

invention showing multiple liners. Case 18 contains high explosive material 12 and a liner combination identified as cascade liner 20. As shown, cascade liner is formed with first liner 22 and second liner 24. First liner 22 is illustrated as a substantially conical element having apex 26 proximate to detonator 16, and having distal end 28 opposite apex 26. Distal end 28 is the open end of cone shaped first liner 22, and faces the open end 30 of case 18. Second liner 24 is shown as a substantially conical element having apex 32 proximate to detonator 16, and having distal end 34 opposite apex 32. First liner 22 is positioned between second liner 24 and explosive material 12.

In one embodiment of the invention, air gap 36 can be made between first liner 22 and second liner 24 for the purpose of providing shock insulation properties. In other embodiments of the invention, other materials such as water, foam, and elastomers can be installed within air gap 36 to accomplish different results. In another embodiment of the invention, high explosive material 12 can be installed within air gap 36 to accelerate the collapse of second liner 24.

To initiate a detonation wave, cord detonator 16 initiates explosive material 12 within booster cavity 38, and explosive material 12 collapses liners 22 and 24. The use of multiple liners such as cascade liner 20 provides significant flexibility in designing shaped charges. For example, different metallic liners can be utilized to modify the form and velocity of the respective metallic jets. Second liner 24 can be constructed from a target penetrating metal such as lead, uranium, tungsten or metal having a similar density, referred to herein and defined as a "heavy metal" First liner 22 can be constructed with a low density material such as aluminum or with a frangible material made with powder techniques, sintered metal,

or other processes. The materials for first liner 22 and second liner 24 can be reversed to accomplish different results, such as increasing jet velocity or creating a pulsating jet.

In a preferred embodiment of the invention, first liner 22 can be constructed from a material having an acoustic impedance substantially equal to the acoustic impedance of explosive material 12. This feature further improves the efficiency of transferring energy from explosive material 12 to the jet formed by second liner 24. This configuration can also be used for producing stable jets from liner materials that would not otherwise produce jets because of low sound velocity or unfavorable geometry of the material.

The use of multiple liners provides significant design flexibility in the selection of materials and in the configuration and penetration of the resulting jets. In a preferred embodiment of the invention, the total weight of liners 22 and 24 can be optimized to obtain the maximum collapse velocity, and is preferably close in weight to the optimal weight of a conventional single liner. This feature would preserve the charge to mass ratio of the shaped charge so that the ultimate jet velocity is substantially unchanged.

First liner 22 and gap 36 can attenuate shock waves, such as the reflections from the inner wall of case 18, which would otherwise interfere with the cohesiveness of the jet. It will be appreciated that additional liners supplementing first liner 22 could be added to the shaped charge to further attenuate undesirable shock wave reflections.

Figure 3 illustrates an alternative embodiment of the invention, wherein cascade liner 40 and explosive material 12 are positioned within case 18. Liner 40 has apex 42 and concentric liner elements 44 and 46. Liner elements 44 and 46 have distal ends 48 and 50

respectively. Gap 52 exists between liner elements 44 and 46 for the purpose described above. As previously described, shock absorbing material 54 can be placed within gap 52 to further attenuate undesirable shock wave reflections.

Figure 4 illustrates yet another embodiment of the invention wherein first liner 56 and second liner 58 are positioned within case 18. First liner 56 is longer than second liner 58, which produces a segmented pulse graphically represented in Figure 4. Such a segmented pulse is particularly suitable for penetrating material such as concrete by creating a "hammering" effect similar to the impact of a jack hammer.

Figure 5 illustrates another embodiment of the invention, wherein the distal ends of liners 60 and 62 are attached to case 18. Detail of this attachment is shown in Figure 6, where the distal ends of liners 60 and 62 are positioned within recesses 64 and 66. This unique feature provides many advantages, including precise control of the jet formation, and precise positioning of liners 60 and 62 within case 18. This positioning is important because the physical relationship between liners 60 and 62 to case 18 and to explosive material 12 affects the formation and effectiveness of the resulting jet.

Figure 7 illustrates another embodiment of the invention wherein first liner 68 and second liner 70 are positioned within case 10. Explosive material 72 is positioned within gap 74 for the purposes described above, and rings 75 retain first liner 68 and second liner 70 within case 10.

While detonator 16 is illustrated adjacent the apex of the liners, the detonation point for explosive material 12 can be positioned at other places sufficient to initiate the formation of a detonation

wave. Different liner configurations and attachment mechanisms can be made to position multiple liners proximate to the explosive material. The shape, composition, and acoustic impedances of the liners, and the configuration of a gap or shock absorbing material between the liners, can be selected to accomplish different objectives related to the size, shape, velocity, and penetration of a jet.

Although the invention has been described in terms of certain preferred embodiments, it will be apparent to those of ordinary skill in the art that modifications and improvements can be made to the inventive concepts herein without departing from the scope of the invention. The embodiments shown herein are merely illustrative of the inventive concepts and should not be interpreted as limiting the scope of the invention.

CLAIMS

1. A shaped charge for producing a material penetrating jet in response to a detonator, the shaped charge comprising:

an explosive material formed about an axis which material can be intiated by a detonator to create a detonation wave;

a first liner proximate to said explosive material; and

a second liner, proximate to said first liner, and collapsable about a hollow center, when impacted by such a detonation wave and said first liner, thereby generating a material penetrating jet.

2. A shaped charge as claimed in Claim 1, wherein said first and second liners substantially comprise metals having different acoustic impedances.

3. A shaped charge as claimed in Claim 1 or 2, wherein said first liner is formed with a material having an acoustic impedance substantially similar to the acoustic impedance of said explosive material.

4. A shaped Charge as claimed in Claim 1 or 2, wherein said first liner is formed with a frangible material.

5. A shaped charge as claimed in any one of Claims 1 to 4, wherein said second liner is formed with a heavy metal.

6. A shaped charge as claimed in any one of the preceding claims, wherein said second liner is smaller than said first liner.

7. A shaped charge as claimed in any one of the preceding claims, wherein said first and second liners are integrated into a single liner system having at least two coaxial liner elements extending radially outwardly from a single, closed end toward two separate, open distal ends.

8. A shaped charge as claimed in any one of the

preceding claims, comprising a charge case for containing the explosive material, and wherein said first and second liners are engaged with said charge case.

9. A shaped charge as claimed in any one of the preceding claims, wherein said first and second liners are positioned so that a gap exists between said first liner and said second liner.

10. A shaped charge as claimed in any one of the preceding claims, comprising a shock absorbing material between said first liner and said second liner.

11. A shaped charge as claimed in any one of claims 1 to 9, comprising a high explosive material between said first liner and said second liner.

12. A shaped charge for initiating a material penetrating jet in response to a detonator, the shaped charge comprising:

a case having an open end;

an explosive material positioned within said case about an axis, and activatable by a detonator, thereby to create a detonation wave moving substantially parallel to said axis;

a first liner in contact with said explosive material, wherein said first liner has an apex proximate to the detonator; and

a second liner proximate to said first liner, and having an apex and a distal, open end opposite said apex the second liner being collapsable about a hollow center, when impacted by said detonation wave, thereby generating a material penetrating jet.

13. A shaped charge as claimed in Claim 12, wherein said first and second liners are integrated into a single liner system having at least two coaxial liner elements extending radially outwardly from a single, closed end toward two separate, open distal ends.

14. A shaped charge as claimed in Claim 12 or 13, wherein the distal end of said second liner is attached to said case.

15. A shaped charge as claimed in Claim 12 or 13, comprising a shock absorbing material between said first liner and said second liner.

16. A shaped charge as claimed in Claim 12, 13 or 14, further comprising an explosive material between said first liner and said second liner.

17. A shaped charge as claimed in any one of claims 12 to 16, wherein said second liner is smaller than said first liner.

18. A shaped charge for initiating a material penetrating jet in response to a detonator, comprising: a case having an open end; a liner system within the open end of said case, wherein said liner system has an apex proximate to a detonator, and wherein said liner comprises at least two coaxial liner elements extending outwardly from said apex toward separate, distal ends of said liner elements; and an explosive material positioned between said case and said liner system, wherein said explosive material can be initiated by the detonator to create a detonation wave for collapsing said liner system to create the jet.

19. A shaped charge as recited in Claim 18, wherein said liner system is engaged with said case.

20. A shaped charge as recited in Claim 18, further comprising a gap between said coaxial liner elements.

21. A shaped charge substantially as hereinbefore described with reference to Figures 2 to 7 of the accompanying drawings.

The Patent Office

11

Application No: GB 9615704.5
Claims searched: 1 to 21

Examiner: R C Squire
Date of search: 23 October 1996

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): F3A

Int Cl (Ed.6): F42B; E21B

Other:

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 916870	SCHLUMBERGER (see figures 2 to 6)	1,12,18 at least
X	GB 832685	SCHLUMBERGER	1,12,18 at least
X	EP 0437992A	ETAT-FRANCAIS	1,12,18 at least
X	EP 0156090A	ISRAEL	1,12,18 at least
X	EP 0105495A	SKOLNICK	1,12,18 at least
X	US 5119729	NGUYEN	1,12,18 at least

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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